EVALUATION OF MINING AND RECLAMATION PLAN FOR ANACONDA JACKPILE-PAGUATE MINE NEAR VALENICA COUNTY, NEW MEXICO

SUBMITTED TO
PUEBLO OF LAGUNA
O'LAGUNA, NEW MEXICO

SUBMITTED BY
KILBORN/NUS
DENVER, COLORADO

OCTOBER 26, 1979

Prepared by: Constance V. Braun
Constance V. Braun
Project Manager

Approved by: Terrold W. Conway
Terrold W. Conway
Manager, Westcentral
Environmental Center

Approved by: K. H. Campbell
Kenneth H. Campbell
Acting President
Kilborn/NUS, Inc.

TABLE OF CONTENTS

FOREWORD

At the request of the Pueblo of Laguna, Kilborn/NUS has completed a comprehensive review and evaluation of the Mining and Reclamation Plan for Anaconda Company's Jackpile-Paguate Uranium Mine in Valencia County, New Mexico prepared by Dames & Moore in December, 1976 and revised March, 1979. This comprehensive review was based on the lease agreements between the Pueblo and Anaconda made during the period March 27, 1952 to July 6, 1976. These agreements stipulated that Anaconda comply with regulations of the Secretary of Interior including 25 CFR 171, 25 CFR 177.7 and 30 CFR 231. Members of the Kilborn/NUS project team made two site visits to the Jackpile-Paquate Mine on March 26 and May 22, 1979, and contacted Mr. Marc Nelson of the U.S. Geological Survey on several occasions. Since the regulations lack specificity in regards to reclamation requirements, state-of-the art reclamation technology and professional judgment were used as the basis for evaluation of the proposed reclamation plan in addition to the evaluation of the feasibility of the proposed plan to achieve the stated reclamation objectives.

INTRODUCTION

The Kilborn/NUS review and evaluation of the Mining and Reclamation Plan for the Anaconda Jackpile-Paguate Uranium Mine in Valencia County, New Mexico emphasized the following:

- o Surface and subsurface water impacts and management plans.
- o Radiological impacts.
- o Long and short term socioeconomics impacts.
- o Waste disposal and abandonment aspects of the mine plan.
- o Feasibility of the reclamation plan to restore the mined land.

The results of this evaluation are presented in the following three sections. Section 1.0 evaluates compliance by Anaconda Company with all applicable Federal and state regulations and any agreements between the Pueblo of Laguna and Anaconda regarding reclamation. Section 2.0 discusses the feasibility of the plan to ensure environmental protection of existing natural resources. Section 3.0 presents recommendations and alternatives specific to final reclamation and revegetation.

SECTION 1.0. COMPLIANCE WITH APPLICABLE FEDERAL AND STATE REGULATIONS

Environmental and reclamation stipulations in the lease agreement include compliance with regulations 25 CFR 171, 25 CFR 177.7 and 30 CFR 231 and the statement that Anaconda may terminate the lese upon "a showing satisfactory to the Secretary of the Interior or his authorized representative that full provision has been made for the conservation and protection of the property". Those sections of 25 CFR 177 promulgated in 34 FR 813, January 18, 1969, prior to the July 6, 1976, lease agreement would appear to be applicable to Anaconda's operations although only 25 CFR 177.7 is included in the lease. The applicability of 25 CFR 177 is less important since the regulations address general provisions of the mining plan rather than specific reclamation performance standards.

The open-pit mining operations actually began in 1953 which was well in advance of the National Environmental Policy Act of 1969, the establishment of the New Mexico Improvement Agency in 1971, the promulgation of the US Geological Survey (USGS) Operating Regulations 30 CFR 231 in 1972, and the present and productive state. Consequently, a baseline characterization of natural resources in the Jackpile-Paguate Mine area prior to mining operations is not available. This lack of information is somewhat limiting in assessing present conditions.

Water Resources

The following guidelines with respect to water resources were extracted from the USGS Operating Regulations 30 CFR 231:

- All operations under the regulations shall be consistent with both Federal and state water quality standards.

- The mining plan requires:
  - An estimate of the quality of water to be used and pollutants that are expected to enter any receiving waters.
  - A design for the necessary impoundment, treatment or control of all runoff water and drainage from workings so as to reduce soil erosion and sedimentation and to prevent the pollution of receiving waters.

- o The reclamation plan should address plans to avoid, minimize, or correct hazards to public health and safety.

The National Pollutant Discharge Elimination System (NPDES) is applicable to Indian lands. A NPDES permit is required if there is discharge to surface streams in the area.

The Mining and Reclamation Plan is consistent with Federal and state water quality standards. In terms of major water use, a maximum of 15 million gallons per year has been sprayed on the dirt roads for dust control in the mine area; however, no estimate of pollutant quantities entering the Rio Paguate or the Rio Moquino were presented in the Dames & Moor report (1976; 1979). No special controls to reduce soil erosion and sedimentation from reaching the perennial streams were presented, but direct runoff to the streams is inhibited since the mining operation is open-pit. Some ore piles have been placed near the banks of the Rio Paguate which further increases the potential for contaimination of receiving waters as a result of rainfall runoff.

Potential sources for irrigation water include the sewage lagoons and Rio Paguate. Water from the sewage lagoons is not sufficient to supply irrigation water (Appendix A). USGS data (1938 - 1941) indicate an average annual flow of 753 acre-feet which could supply irrigation for a similar number of acres for reclamation use (based on an irrigation rate of 12 inches/acre). Due to the variation in stream flow during the growing season, a storage reservoir would be needed to retain water resulting from snow melt or summer storms which could then be used during the dry summer months when stream flow is minimal. Because the Rio Paguate stream flow data are scanty (1938 -1941) and the economics of building a storage reservoir unknown, water availability should be further investigated before planning to irrigate revegetated areas.

Air Resources

The USGS guidelines which apply with respect to air quality include:

- o All operations conducted under the regulation in this part must be consistent with Federal and state water and air quality standards.
- o A description of measures to prevent or control fire, soil, erosion, pollution of surface and groundwater, pollution of air must be included.

The general climatological description was found to reasonably represent the region in which the mine is located. A more detailed precipitation summary should have been provided. Monthly maximum and minimum totals for the 20-year data base from Laguna would have more adequately provided input for the revegetation assessment.

Since the onsite wind data can be used for dispersion analysis, the representativeness and accuracy of these data need to be addressed. Data recovery rates, sensor specifications, calibration results, etc., would need to be evaluated to make this assessment.

The site has monitored Total Suspended Particulates (TSP) from February 1973 to November 1978 as specified by the USGS. It is unclear whether modelling results were used to determine the monitoring locations and therefore, whether monitors are located in areas of maximum expected concentrations along the boundary. The data were not collected on a schedule generally accepted; EPA generally accepts a sample every 6 days, as a minimum. During the period of February 1973 to November 1978 (70 months) it was indicated that 61 "monthly 24 hour concentrations" were collected. This appears to be less than once a month and the data cannot be used to determine compliance. The limited data presented suggest that the 24-hour standard which is not to be exceeded more than once per year has been violated.

The following means are presented for the west side sampling:

Period	Mean TSP $\mu g/m^3$
2/73 - 11/78	73.1
10/76 - 11/78	35.9

Since the two data periods overlap and the period of 10/76 - 11/78 is much lower than the total period of 2/73 - 11/78, it is suggested that during the period of 2/73 - 9/76 that the particulate levels were high, quite possibly higher than the annual primary Federal Standard of 75 $\mu g/m^3$ which is based on

a geometric mean. Therefore, data should be presented on an annual basis in order to better evaluate whether Federal ambient air quality standards are being met.

TSP is considered to be the pollutant with significant potential to exceed the standards. The projected increase of nearly 100 percent in ore processing could result in violations of the standards. It would be necessary to review dispersion modelling for this project to quantitatively evaluate the expected impact. An analysis of increased mining activity in relation to the increase in the size of the area's emission source would be a key factor in determining expected increases in concentration.

The mine plan must contain a particulate control plan which would allow operations to be conducted within Federal and state standards. The control plan described in the Permit to Mine does not ensure compliance in that it does not appear to be an enforceable provision of the mine plan. Watering "as required" does not ensure compliance. If watering were conditioned to precipitation events, wind, opacity, etc. it would be possible to assess the effectiveness. Watering in this arid area would appear to be a difficult control strategy. The efficiency of the stablizer SS-KH cannot be assessed since the surface area of the application was not specified.

If all permits were obtained for this expanded mine plan prior to March, 1978 and commencement and continuous development of activities associated with this mine plan were conducted prior to March, 1979, a Prevention of Significant Determination (PSD) Permit from EPA would not apply to this project. If this were not the case, PSD would have to be considered in this review since it would be an applicable regulation.

RADIOLOGICAL CONSIDERATIONS

There are no Federal or state regulations which specifically address radiological aspects of uranium mine reclamation on Indian lands. USGS has identified several guides for radiological evaluation of the proposed reclamation procedures (Nelson et al. 1978). These include:

- 10 CFR Part 20 - Maximum Permissible Concentrations (MPCs) (air) for radon of 30 pCi/l in restricted areas and 1 pCi/l (0.01 WL) in unrestricted areas to populations (above background levels,

averaged over no more than one year); these have been interpreted by USGS to mean restricted area MPCs apply to mining and unrestricted MPCs apply to post-reclamation time periods, respectively. Evaluation of the reclamation plan therefore would consider unrestricted area MPCs. [Other federal guidance/regulations (FRC, EPA, BuM, MESA, MSHA) on radon levels are all higher than the unrestricted area MPC's.]

- 10 CFR Part 20 - Radiation dose limits (external, whole body) of 2 mrem/hour, 100 mrem in any seven consecutive days, or 500 mrem in one calendar year to an individual.

- 10 CFR Part 20 - MPCs, (air) for unrestricted areas of:
  Thorium-230 = 8×10^{-5} pCi/l
  Radium-226 = 3×10^{-3} pCi/l
  Uranium-238 = 3×10^{-3} pCi/l
  Uranium-234 = 2×10^{-2} pCi/l
  Lead-210 = 4×10^{-3} pCi/l

- 10 CFR Part 20 - MPCs (water) for unrestricted areas of:
  Radium-226 = 30 pCi/l
  Radium-228 = 30 pCi/l
  Thorium-230 = 2000 pCi/l
  Lead-210 = 100 pCi/l
  Uranium-234 = 3×10^{4} pCi/l
  Uranium-238 = 4×10^{4} pCi/l
  and also New Mexico Water Quality Control Commission limits of:
  Total Uranium = 5 mg/l (dissolved portion only)
  Combined Radium -226 and -228 = 30 pCi/l (dissolved portion only)

No specific radon emanation (or emission) rate is identified; ambient concentration is used for evaluation (first item above).

The mining plan (Dames & Moore 1979) indicates the open pit will be backfilled to a depth where the ore-bearing zone is completely covered. USGS has stated (Nelson et al. 1978) that three feet of overburden above the ore-bearing zone is the minimum backfilling deemed acceptable for radon emission control.

EPA measurements of ambient radon concentrations onsite and in the nearby vicinity (Eadie et al. 1978) indicate present concentrations are below the guideline levels, although a very limited amount of onsite data exists. Anaconda has committed to a regular radon monitoring program (Gray 1978) which would include a reclaimed waste pile, two perimeter locations, and near an active mine vent. On the basis of the presently limited data, the mine complex meets the ambient radon concentration guideline.

It is expected that after reclamation that the mine complex would also meet this guideline with the USGS-imposed three foot minimum overburden coverage in place.

Gamma radiation surveys and air and water analyses (Eadie et al. 1978) indicate that present levels in the vicinity of the mine complex are below the guidelines stated above. Insufficient onsite measurements have been made to draw appropriate conclusions for reclaimed areas but commitments to monitoring programs have been made. It is expected that the mine complex after reclamation would meet the air and direct radiation guidelines with the USGS-imposed three foot minimum overburden coverage in place. It is not expected that concentrations in water would increase after removal of the low-grade ore stockpiles and after reclamation has been completed in accordance with the proposed mine plan.

It is therefore concluded that the reclamation proposed in the present mine plan, in conjunction with USGS-imposed requirements for overburden backfilling, would meet the radiological guidelines.

Socioeconomics

The applicable USGS Operating Regulations 30 CFR 231 do not specifically address the socioeconomic impacts. There are no state regulations that require socioeconomic impact evaluations of uranium mining operations.

Mining and Reclamation

The USGS Operating Regulations 30 CFR 231 primarily address the information to be contained in the Mining and Reclamation Plan. The Lessee has an obligation

"to avoid, minimize, or repair soil erosion, pollution. . . damage. . .injury or destruction. . ." to natural resources. No reclamation standards are set forth in these regulations. The regulations only state that "the surface of leased or permit lands shall be reclaimed in accordance with the terms and conditions prescribed in the lease or permit and the provisions of the approved exploration or mining plan". Therefore, the reclamation standards for the Jackpile-Paguate Mine will be set forth in the Anaconda Mining and Reclamation Plan as approved by the Pueblo of Laguna.

Observations of the present mining operations indicate that mining is being conducted according to the "good practice" specified in the USGS regulations.

SECTION 2.0 ENVIRONMENTAL PROTECTION

The Mining and Reclamation Plan was reviewed to determine the feasibility of the plan to ensure the environmental protection of the area of the Jackpile-Paguate Mine. An evaluation was conducted to determine the potential for environmental impacts to result from mining activities and a determination was made regarding the need for mitigation procedures. The monitoring programs were evaluated to assess their effectiveness in detecting impacts on the existing natural resources.

Impacts are typically identified as events or changes occurring as a result of some activity, e.g., uranium mining at the Jackpile-Paguate Mine. Impacts are detected by comparing operating conditions to pre-activity conditions. Such a comparison is not possible for the Jackpile-Paguate Mine since a baseline characterization of the pre-mining natural resources is not available. Data regarding the natural environment are limited to those collected since 1970 and therefore, comparisons are limited to those made with natural surrounding areas. Therefore, an assessment of the effectiveness of the plan to ensure environmental protection relies heavily on professional judgement.

Water Resources

Surface and groundwater resources in the Jackpile-Paguate Mine area are not extensive. Most streams in the San Juan Basin are ephemeral with the exception of perennial flows in Rio Paguate and Rio Moquino. Average annual precipitation is estimated to vary over the watershed from less than 10 inches near the mine to more than 25 inches near Mount Taylor. Correspondingly, the estimated average runoff from the watershed is about 9,800 acre-feet per year or an average discharge of about 13.5 cubic feet per second as the Rio Paguate exits in the mine area (Dames & Moore 1976). Data characterizing the water resources at the Jackpile-Paquate Mine are sparse and are available only for sporatic time periods. Therefore, the data are not always conclusive.

The average discharge at a gaging station on the Rio Paguate above the confluence with the Rio Moquino and two miles northwest of Paguate village

was 1.71 cubic feet per second for the years 1938 thru 1941. The maximum recorded discharge was 61 cubic feet per second in 1941 and the minimum recorded discharge was 0.2 cubic feet per second in 1938 (Reiland & Haynes 1963). Wells in the Morrison Formation and the Quaternary alluvium supply groundwater for use in the mine area. Yields vary from 5 to 100 gallons per minute or 0.01 to 0.223 cubic feet per second, respectively (Nelson et al. 1978). In order to establish a perspective, Table 1 shows water requirements for various irrigation and soil types (Todd 1970). The soil type for the Paguate Irrigated Unit is probably between a coarse sandy soil and a light sandy loam. Therefore sufficient water is not available to expand present cultivation.

Surface water samples in the vicinity of the Jackpile-Paguate Mine typically exceed 500 ppm in TDS (total dissolved solids) and 250 ppm in sulfate. The water quality in the Rio Paguate above the confluence with Rio Moquino is lower in both TDS and sulfate for the same period of measurement, but TDS concentrations usually exceed public water supply standards of 500 ppm (Dames & Moore 1976; revised 1979). The water quality in the Morrison Formation ranges from poor to fair. "Poor" means water having TDS and sulfate concentrations greater than 1,000 ppm and 300 ppm, respectively. "Fair" means water containing 500 to 1,000 ppm TDS and less than 300 ppm sulfate. The public water supply for Paguate village is obtained from groundwater in alluvium deposits near Rio Paguate upstream from the village and the mine.

The mining operation has affected the quality of both surface water and groundwater in the vicinity of the mine. The concentration of uranium in the Rio Paguate increases somewhat while flowing through the mining area. The increase in concentration is apparently due to groundwater seepage and surface runoff from waste piles (Nelson et al. 1978). Two holding ponds for dewatering pumpage and one sewage lagoon are used to hold liquid wastes. A two-year hydrologic study was recently completed by Hydrosearch, Inc. and a report should have been submitted to Anaconda Company during Spring 1979. This report was not reviewed by Kilborn/NUS. "The basic objective of the study was to determine the fate and influence of water pumped out of mining operations and stored in liquid waste storage facilities on

TABLE 1. WATER REQUIREMENTS FOR VARIOUS IRRIGATION AND SOIL TYPES.

Irrigation type	Slope land per cent	Coarse sandy soils		Light sandy loam		Medium silt loam		Clay loam soils		Very heavy clay soils	
		Q per unit	Length of run	Q per unit	Length of run	Q per unit	Length of run	Q per unit	Length of run	Q per unit	Length or run
Basins*	0-2	20 cfs per acre		7.5 cfs per acre		5 cfs per acre		3 cfs per acre		2 cfs per acre	
Borders* or checks . . .	0-2	1.5 cfs per 10' width	220'	.75 cfs per 10' width	440'	.5 cfs per 10' width	550'–880'	.33 cfs per 10' width	660'–880'	.3 cfs per 10' width	1,000'
Furrows.	0-2	.02 cfs per each	220'	.01 cfs per each	330'	.01 cfs per each	440' 660'	.008 cfs each	660'	.005 cfs per each	880'
	2-5			.005 each	220'	.005 per each	220' 440'	.003 per each	440'	.003 per each	550'
	5-8					.002 per each	110' 220'	.001 per each	330'	.001 per each	330'
Sprinkling	0-2	2" per hour		.75" per hour		.5" per hour		.2" per hour			
	2-5	2" per hour		.75" per hour		.5" per hour		.2" per hour			
	5-8	1.5" per hour		.5" per hour		.4" per hour		.15" per hour			
	8-12	1.0" per hour		.4" per hour		.3" per hour					

*The range in slope 0-2 per cent is in itself a very rough picture of field practices where the actual slopes, particularly with borders, tend to be closer to .2 or .3 per cent rather than this higher limit 2 per cent.

SOURCE: Todd (1970).

ground water levels and quality and on the quality of the Rio Moquino and Rio Paguate" (Dames & Moore 1976; revised 1979). The report should further quantify the impacts of mining operations on the local water resources and is needed to understand the effects of mining operations on surface and groundwater.

Air Resources

Air quality environmental effects of this mining project are mainly concerned with TSP levels. Other regulated pollutants are not expected to be significant beyond the lease boundaries.

The increase in mining activity could significantly affect visibility and dust in the area, particularly in the village of Paguate. The mine plan indicates that residents of Paguate have experienced problems with dust from the mine.

It is not certain that the National Ambient Air Quality Standards which were established to protect the health and welfare of the population are currently being met, based upon limited data presented in the mine plan (See Section 1.0). It is felt that the proposed mine expansion could result in ambient levels in excess of the standards. To assess environmental impact, it would be necessary to review the dispersion analysis for this project. The impact of the increased mining will depend, among other factors, on the degree of particulate controls on an ongoing basis.

Much of the weight of the samples collected by the hi-volume samplers at the Jackpile-Paquate Mine is expected to be associated with relatively large heavy particles of native soil (greater than 10 microns in diameter). These large particles are not generally deposited in the lower respiratory tract where gas exchange occurs (Miller et al. 1979). Therefore, the TSP levels at the Jackpile-Paquate Mine would not be considered to be a health hazard to the general population.

Based upon these considerations, the most adverse impacts of the mining operation on the village of Paguate are expected to be reduction in visibility and an increase in settling dust. Although the health effects issue is

still being reviewed on a federal level, it would not be expected that this mining operation would have a significant effect on the health of the general population of Paguate.

With an effective reclamation plan, there should not be significant long-term impacts on air quality associated with this mining operation.

Soils, Vegetation, and Wildlife

The characterization of the vegetation and wildlife in the vicinity of the Jackpile-Paguate Mine indicated that no unique, rare or endangered plant or animal species is likely to occur in the area or depend on the area as critical habitat. This conclusion was supported by the U.S. Fish and Wildlife Service and regional experts (Nelson et al. 1978).

Socioeconomics

A detailed socioeconomic impact analysis of the proposed action on the Pueblo of Laguna has not been conducted. It is known that mining operations at the Jackpile-Paguate Mine employ approximately 70 percent Pueblo Indians. According to 1975 Laguna Indian Reservation population and employment statistics, each employed person living on the reservation supports five other persons. Of the estimated 738 employed persons living on the reservation, 347 persons or approximately 47 percent work at the Jackpile-Paguate Mine. Therefore, the importance of the Jackpile-Paguate Mine operations to the economic welfare of the reservation residents is obvious. The short-term impact of the mining operation (till 1983 to 1985) will be to provide economic stabilization to the tribe as a result of employment opportunities, royalty payments, and material betterment. Following shutdown of the mine, Indians presently employed by the mine will be forced to seek employment elsewhere.

The reclamation plan has been reviewed in terms of assessing the feasibility of proposed future land uses. The soils information indicates that of the irrigable soils (Paguate Irrigated Unit), "54 percent (154 acres) have few or no restrictions for irrigation purposes while the remaining 131 acres require

extensive conservation management practices to sustain soil productivity" (Dames & Moore 1979). Coupled with this is the fact that water resources are limited. Although more sophisticated irrigation methods have been developed for arid environments e.g., drip irrigation, this method would appear to have limited usage since only 288 acres are suitable for cultivation. However, drip irrigation may be useful for the establishment of woody species in the reclamation program.

Existing mining structures which will be left intact at the cessation of mining could be converted into an automotive repair center or similar tourist-related stores and facilities. Such developments would not provide a major economic alternative to the present mining.

Due to the marginal suitability of the soil resources for cultivation and the limited water resources, grazing is the highest use for the reclaimed mined land. The configuration of the waste dump, although causing a small percentage loss in acreage for grazing use, will allow better grazing management practices to be implemented. Reduced access to the upper areas of the waste dumps will permit rest-rotation grazing methods to be used and therefore prevent long-term overgrazing.

Radiological Considerations

The principle consideration for radiological environmental impact is postmining land use restriction, if any. If reclamation enables unrestricted use of the land from a radiological standpoint, environmental impact would not be considered radiologically significant. Other considerations (primarily water availability) dictate that grazing is to be the principle land use after reclamation. Occupancy, farming, etc., are not considered likely.

Since at least three feet of overburden would be placed above the ore-bearing zone, it is not likely that significant radioactivity would be uptaken into vegetation which would be in a pathway to man. The previous removal of much of the ore-bearing material (the objective of the mining process) would mean that typical overburden thicknesses to a depth where substantially higher than background amounts of uranium would be present would actually be much

greater than three feet. Few vegetative species have root structures greater than three feet with greasewood (Sarcobatus vermiculatus) the only likely indigenous exception and it is not a dominant plant species in the area. Analyses of chemical and radiological content of species in the reclaimed areas will be conducted in response to USGS requirements (Gray 1978); these would enable corrective action if a particular vegetative species were found to have sufficiently high radioactivity content.

The USGS requirement to have ambient radon concentrations less than 1 pCi/l would also likely obviate the need for restrictions against occupancy of the reclaimed areas.

Mining

During the mine life to date (26 years), open pit mining including support facilities has been conducted on 1,085 acres with waste material deposited on 1,193 acres. The open pit ultimately will disturb 2,139 acres. This disturbance by mining in the open pit is fixed by the deposit shape and therefore the pit design. The waste dumps will ultimately increase by 146 acres to 1,339 acres. This could possibly be reduced very marginally by placing a slightly larger amount of material within the pit or by raising the dumps to greater heights. The current plan calls for placing a major portion of the waste stripping back in the mined out areas of the pit. Therefore, only a very marginal improvement would be possible.

There are a number of areas where the pit walls have been mined at a steep angle over extended vertical distances. These are stable and tend to conform with the mesa topography of the area. Therefore, flattening these slopes would have no advantage and would only result in greater areas which would be disturbed and require reclamation.

Pit bottom elevations are not given on drawings so it is difficult to determine where highwalls will be left, but it is probably not feasible to break the highwalls sufficiently to construct dwellings in the area. Pit depth appears to be in the order of 150 feet. It would be more advisable to leave a perimeter around the pit and build on undisturbed areas near the pit

rather than on flattened pit slopes. A pit slope consisting of rock with a 1:1 slope will remain stable at the Jackpile-Paquate Mine.

The underground mining will create little rehabilitation problems. The waste dumps will be part of the main dumps. The actual mine workings will be sealed after abandonment to prevent entrance. The disturbed areas will be within those areas which will be disturbed by open pit mining.

One problem which must be considered is that surface subsidence may take place. This movement will not necessarily be readily noticeable but can be expected. Masonry structures should not be constructed on these areas. Frame buildings may not be structurally damaged. This subsidence should not create problems in use for agriculture as it will not be sufficient to effect drainage courses.

The ultimate disposition of the low-grade stockpile No. 1 should be a major consideration since it is presently uneconomic to treat. This material should be left in a manner which will permit shipping of this stockpile if economics permit. The mine plan states that all lowgrade ore piles will be removed at the cessation of mining. Since it may not be economically feasible to process all the lowgrade ore at that time, it is unclear what the final disposition of the material will be at that time.

The section of the mine and reclamation plan on water requirements indicates that the watershed has been blocked and disrupted by mining operations within the mine area. The water from underground operations to date is minimal. The P-10 mine produced 60-65 gpm in 1976. With the completion of underground mining, there will be no water discharge and therefore no ongoing problem from underground mining but surface drainage may require remedial action.

The major deficiency in the Mining and Reclamation Plan (Dames & Moore 1976; 1979) is its generality. This apparent hesitancy to be specific probably reflects a desire to maintain flexibility in operations. Although this approach is understandable, more details regarding the final abandonment plan such as fencing, underground mine closure, and slopes in the open pit area, is needed to ensure the long-term health and safety of the Pueblo of Laguna and protection of the natural environment.

Reclamation

The reclamation plan exhibited a lack of specificity similar to that found in the mining plan. Although flexibility is desirable, the basis for enforcement by USGS is the approved reclamation plan. Therefore, it is imperative that the reclamation plan present a clear and detailed reclamation program.

Reclamation technology is expected to further develop during 1979 to 1985. Improved technology can be incorporated into the reclamation plan by "mutual consent of the mining supervisor and the operator at any time to adjust to changed conditions...". The additional specificity needed includes: final slopes and elevations, particularly slopes in the area of the open pit, height of highwalls, fencing specifications, and depths of protective covering or "topsoil" at each disturbed area. A map of the reclaimed area showing final contours would clarify the needed information.

An important element in overall environmental protection of the mine area is the timeliness of the reclamation program. Table 5.2-2 (Dames & Moore 1979) indicates that reclamation activities appear to be scheduled at the earliest feasible time.

An evaluation of the post-mining land use of the Jackpile-Paquate Mine (above) suggests that grazing is the highest land use for the reclaimed mined land. The following assessment is based on this land use decision.

Discussions related to placement of topdressing material are unclear. The stabilization alternatives presented in Appendix D (Dames & Moore 1979) indicate that the waste dumps and some areas of the open pit will be topdressed but do not specify the depth of material to be used. The revegetation results observed during May 1979 at Waste Dumps C,D,E,F, and G. (not topdressed) suggest that further data or criteria should be made available in order to evaluate whether each of the specified revegetated waste dumps and/or open pits can be successfully revegetated without topdressing. The revegetation failure of Dumps C,D,E,F, and G was apparently related to the toxic chemical properties of the Mancos Shale (Sanchez 1979). This area is scheduled to be reseeded during 1979.

It was stated that two million tons of topsoil (a soil medium suitable for plant growth) have been stockpiled (Dames & Moore 1979). Additional information is needed regarding availability of topsoil on areas to be disturbed in the future. It appears that sufficient topsoil, eg. Tres Hermanos overburden, is not available to topdress all the waste dump and open pit areas. Therefore, it is essential that careful estimates of topsoil availability be developed prior to finalizing plans for location and depth of topsoil placement.

A review of the revegetation techniques (e.g., seeding mixture and rate, mulch, etc.) indicates that the plan generally incorporates the most up-to-date technology. Table 2 presents the seed mixtures used at the Jackpile-Paquate Mine during the past three years; the plant species included in these mixtures differ from those presented in Table 5.4-2 of the reclamation plan (Dames & Moore 1979). Specific seed mixture/s and rates should be presented in the reclamation plan. The eight to ten pounds pure live seed per acre seeding rate (Sanchez 1979) appears low. The suggested minimum seeding rate for drilling critical areas is 13 pounds pure live seed per acre (Lohmiller 1971).

Anaconda is presently testing additional plant species for seeding and for containerized material (Sanchez 1979). Winterfat, Australian saltbush, quailbrush, galleta, buffalo grass, and plains bristlegrass will be seeded during 1979. Winterfat, Australian saltbush, quailbrush, juniper, and galleta will be tested as containerized material on slopes and surfaces. These experiments may provide additional species for use in the reclamation program.

The establishment success of the plant species seeded at the Jackpile-Paquate Mine indicates that the revegetation potential is poor to good depending on the precipitation in a given year. The long-term establishment of vegetation in a disturbed mined area is presently unknown. A species adaptability study conducted by Springfield (1965) at five pinyon-juniper sites in New Mexico indicated that western wheatgrass, blue grama, alkali sacaton, and fourwing saltbush survived for 12 years at sites similar to the Jackpile-Paquate Mine area.

TABLE 2. SEEDING MIXTURES USED DURING 1976-1978 AT THE JACKPILE-PAGUATE MINE[1].

Plant Species	Percent Composition 1976	1977	1978
GRASSES			
Agropyron cristatum	--	15	--
Agropyron smithii	5	--	10
Andropogon hallii	6	--	--
Andropogon scoparius	15	--	--
Bouteloua curtipendula	4	--	10
Bouteloua gracilis	30	25	30
Eragrostis curbula	10	15	15
Oryzopsis hymenoides	5	10	10
Sporobolus airoides	5	15	15
Sporobolus cryptandrus	15	10	--
FORBS			
Melilotus officinalis	5	--	5
Trifolium sp.	--	5	--
SHRUBS			
Atriplex canescens	--	5	5
TOTALS	100	100	100

[1]Sanchez (1979).

The arid conditions at the Jackpile-Paquate Mine make it essential that techniques be utilized which will maximize soil moisture conditions for germination and establishment. This can theoretically be accomplished by supplemental irrigation, mulch, or various mechanical surface manipulations. Irrigation on a large-scale appears doubtful although water resources may be available to irrigate approximately 750 acres per year of revegetated areas (12 inches/year) based on limited data from 1938 - 1941 (Dames & Moore 1979). Drip irrigation could be used to establish woody plant species which may be an important method for achieving slope stabilization. Barley straw mulch at two tons per acres is presently being applied on all revegetation sites (Sanchez 1979) and appears to be effective. The use of mechanical surface manipulations which provide microsites for seed germination could be important at the Jackpile-Paquate Mine during years with abnormally low precipitation patterns. Hodder et al. (1972) has investigated three surface manipulation techniques; gouging, dozer basins, and deep chiseling and combinations of these three. Similar techniques could be beneficial in improving revegetation success at the Jackpile-Paquate Mine.

The evidence of erosion on the slopes of the waste dumps indicates that these slopes are not stable at the present angle of repose. These slopes present a critical problem in long term stabilization. Methods which could be used to stablize the slopes include: reduction of slope angle, benching or terracing, covering with large aggregate material, use of protective covering, e.g., matting, or vegetative stablization. Economics will obviously influence the final choice of stablization techniques. Cost estimates to reduce the slopes to a 3 to 1 grade range from $963 to $3,816 per acre depending on the method of slope reduction (Gray 1978). Cost estimates for benching are not available but they would be expected to fall within or below the above range. It may be feasible to construct benches alongside existing dumps with material newly excavated during the next several years and therefore, reduce costs since such material will require disposal. The use of large aggregate material would preclude the possibility of most vegetation establishment and is therefore, less desirable than the other options. Protective covering, e.g. matting, or netting, will reduce short-term erosion, but unless vegetation is successfully established, this method will not prevent long term erosion problems. The potential of matting to enhance vegetation establishment at the Jackpile-Paquate Mine is presently unknown but is scheduled to be tested

during 1979 (Sanchez 1979). A type of matting or netting may be needed in conjunction with any revegetation efforts. The ability to establish vegetation which can successfully prevent erosion on a 1:1.3 slope is highly questionable. The 1:1.3 slopes probably cannot be topdressed thus further limiting the revegetation potential in these areas. If vegetative stabilization is the method selected, juniper trees and other native woody species should be included in the revegetation program. Juniper is an important native species in the area and could be expected to enhance overall stabilization. Various techniques have been investigated to enhance establishment of containerized shrub material in the Southwest (Aldon & Springfield 1975). Unless vegetative stabilization can be clearly demonstrated in the next two to three years, it appears that a combination of terracing and vegetative stabilization could provide the most acceptable method to stabilize the slopes of the waste dumps.

The reclamation plan does not contain short term management plans which provide for subsequent fertilization or weed control. Soil tests for nitrogen, phosphorus and potassium should be repeated during the second year or third year after seeding to determine nutrient availability. Fertilizer may need to be applied at subsequent intervals after the initial fertilization. "Weedy" species have been demonstrated to exert harmful competition with seedlings of desirable plant species, particularly if the weed species is Kochia (Quimby 1971). Observations of reseeded areas at the mine indicate that weedy species represent a dominant portion of the existing vegetation. The vegetation on an area of waste dumps C,D,E,F, and G scheduled for reseeding during 1979, consisted primarily of Russian thistle and Kochia. Thus, weed control could be an important part of the reclamation plan.

Long term management of grazing will ultimately determine revegetation success and the ability of the reclaimed mined land to support productive land uses. Revegetated areas should be protected from grazing for a minimum of three to five years after seeding. The proposed reclamation of the waste dumps will improve the capability to practice rest-rotation grazing

on the reclaimed lands. The slopes of the waste dumps will not support grazing but will provide a barrier to prevent indiscriminate grazing. The acreage lost to grazing because of slope structure is expected to be a small percentage of the total disturbed land. Therefore, the various areas of the mine could be grazed on a rotation basis in a manner which would prevent overgrazing and protect the soil and vegetation resources.

The cost estimates for reclamation presented in Appendix D (Dames & Moore 1979) generally appear to be low, particularly those estimates which include equipment operation. It is assumed that estimates are based on present labor and equipment operation costs at the Jackpile-Paquate Mine. Therefore, specific conclusions other than that stated above cannot be made.

The reclamation plan does not address the topic of revegetation failure. Anaconda makes no commitment to reseed areas if revegetation efforts fail. Anaconda has scheduled to reseed an area of Dump C,D,E,F, and G during 1979 which indicates the company's good faith in its objective to achieve successfull revegetation.

If Anaconda is responsible to ensure successful revegetation, then criteria to determine success are necessary. Several phytosociological parameters e.g., percent cover, biomass, or species composition could be used to determine success. Because a baseline characterization was not conducted prior to mining, the use of the revegetation criteria would need to be based on the natural conditions of surrounding areas. Other states such as Wyoming have developed detailed revegetation criteria for reclaimed mined land (Wyoming Department of Environmental Quality 1979). Regardless of the phytosociological criteria selected, they should include species composition since native plant species are the most desirable species to ensure long-term stabilization and productivity.

3.0 RECOMMENDATION

The following recommendations have been developed as a result of the detailed evaluation and review of the Mining and Reclamation Plan for the Jackpile-Paquate Mine. The recommendations include two types. The first are concerned with aspects of Anaconda's Mining and Reclamation Plan while the second addresses aspects which are the responsibility of the Pueblo of Laguna. The recommendations do not necessarily include all topics discussed in Section 1.0 and 2.0 since some items are of lesser importance to the overall objective of successful reclamation.

Recommendations Regarding the Mining and Reclamation Plan

- One 24-hour sample per month for TSP is not considered to be adequate to evaluate compliance with the standards. Sampling would need to be conducted at the locations of maximum concentrations at the site boundary, as indicated by dispersion modeling, every four to six days for at least one year associated with maximum surface mining production. This would be considered as an adequate data base to evaluate compliance with ambient standards. Existing TSP data should be presented on an annual basis.

- The particulate control plan should be more specific regarding conditions which would trigger control response. The rate at which the soil stabilizer SS-KH is to be applied per square foot should be specified.

- Dispersion modeling results should be prepared for the mine plan expansion, including a description of the data used in the analysis (e.g., data recovery rates, specifications, etc.).

- Subsidence monitoring should be requested for underground mined areas and around the pit perimeter. A commitment to have a surveyor remeasure the elevations and record variations would be required on an annual basis until sufficient data are available to show the potential of substantial impacts from subsidence.

- Masonry should not be constructed on mined areas.

- The abandonment plan should be more detailed to provide information such as actual slopes, fencing, and underground mine closure.

- The reclamation plan should be revised to present a detailed plan including placement depth of topsoil, slope configurations, and seed mixtures. A reclamation map showing final contours and elevations should be prepared.

- The highest post-mining land use is grazing.

- Topsoil should be placed to a depth of 18 to 24 inches over all waste dumps, ore stockpile areas, and open pits unless specific physical and chemical soil data are provided for that area which indicates that the area can be successfully revegetated without placement of topsoil.

- Greater use of native woody plant material should be made in the revegetation program; continued use of native species should be made in the seed mixture.

- Mechanical surface manipulations are recommended since they would improve the microsite environment for plant germination and establishment.

- Slopes of waste dumps should be stabilized since erosion will directly affect sediment load in surface runoff to the perennial streams. The most feasible method to achieve stabilization is a combination of surface alterations e.g., terracing and vegetative establishment. Vegetative stabilization on these slopes should include shrub and tree species such as juniper.

- Revegetation criteria of success should be developed to determine adequacy of reclamation.

Recommendations to the Pueblo of Laguna

- The available water resources data are sparse. The limited water resource potential of the Rio Paquate and Rio Moquino watershed could be quantified through additional measured data. The possibility of building small upstream storage reservoirs to integrate the effects of low and high flow could be investigated.

- Estimate the limited water resource potential of the local groundwater basin.

- Prepare a water use plan that coordinates community development and effective management of a limited water resource.

- Further study could be initiated to fully understand the employment and economic development impacts created by mining operations and its subsequent cessation. Employment profiles of the Laguna work force are needed to assess skills and further employment potential. Tribal agriculture, commercial, and industrial developments could be evaluated based on tribal goals and preferences as well as the Indian culture.

- Grazing should be excluded from revegetated areas for three to five years after seeding. Rest-rotation grazing should be implemented thereafter to ensure proper land management.

LITERATURE CITED

Aldon, E.F. and H.W. Springfield. 1975. Using paraffin and polyethylene to harvest water for growing shrubs. In: Proc. Water Harvesting Symp., Phoenix Arizona. March 26-28, 1974. ARS W-22, 329 p.

Blaney, H.F. and E.G. Hanson. 1965. Consumptive use and water requirements in New Mexico. New Mexico State Engineer Tech. Rep. 32.

Dames & Moore. 1976. Mining and Reclamation Plan, the Anaconda Company's Jackpile-Paquate Uranium Mine, Valencia County, New Mexico.

Dames & Moore. 1979. Revised Mining and Reclamation Plan, the Anaconda Company's Jackpile Paquate Uranium Mine Valencia County, New Mexico.

Eadie, G.G, C.W. Fort, and M.L. Beard. 1978. Ambient airborne radioactivity measurements in the vicinity of the Jackpile open pit uranium mine New Mexico. EPA. Las Vegas. 83 p.

Gray, W.E. 1978. Letter to M. Nelson, USGS, Albuquerque, New Mexico dated July 19, 1978.

Hodder, R.L., B.W. Sindelar, J. Buchholz, and D.E. Ryerson. 1972. Coal mine land reclamation research. Montana Agric. Exp. Sta. Res. Rep. 20. 45 p.

Lohmiller, R.G. 1971. Selection of plant materials for roadside stabilization and beautification. In: Proc. of New Mexico Interagency Range Committee's Critical Area Stabilization Workshop, April 26-28, 1971. pp. 71-102.

Miller, F.J. et. al. 1979. Size considerations for establishing a standard for inhalable particles. J. Air Pollution Control Assoc. 29:613.

Nelson, M., J. Andrews, D. Jones, and D. Sitzler. 1978. Environmental analysis: Mining and reclamation plan, Jackpile-Paquate Mining Operations, The Anaconda Company, Pueblo of Laguna uranium mining leases numbers 1,4, and 6. Laguna Indian Reservation, Valencia County, New Mexico. USGS. Albuquerque, New Mexico.

Quimby, P.C. Jr. 1971. Control of weeds in grass on roadsides in New Mexico. In: Proc. of New Mexico Interagency Range Committee's Critical Area Stabilization Workshop, April 26-28, 1971. pp. 174-184.

Reiland, L.J., and G.L. Haynes, Jr. 1963. Flow characteristics of New Mexico streams flow duration, high-flow, and low-flow tables for selected stations through water year 1959, New Mexico State Engineer, Special Report.

Sanchez, C. 1979. Personal communication with C.V. Braun, NUS Corporation on May 22, 1979.

Springfield, H.W. 1965. Adaptability of forage species for pinyon-juniper sites in New Mexico. USDA For. Ser. Res. Note RM-57 4 p.

Todd, D.K. 1970. The Water Encyclopedia, Water Information Center.

U.S. Weather Bureau. 1960. Pan and lake evaporation. Tech. Pap. No. 37.

Wyoming Department of Environmental Quality. 1979. Land Quality Vegetation Guideline No. 2. Cheyenne, Wyoming. 19 p.

APPENDIX A
COMPUTATIONS OF AVAILABLE IRRIGATION WATER

I. Source: Lagoon Water

Assumptions:

1. 325,851 gallons = 1 acre-foot
2. 580,000 gallons of water are available from the lagoon for irrigation (Appendix D, Dames & Moore 1979).
3. Irrigation for revegetated areas is 12 inches/year or 1 acre-foot.

Computations:

$\frac{580,000}{325,851}$ = 1.78 acres

II. Source: Rio Paguate

Assumptions:

1. Rio Paguate annual flow averages 753 acre-feet (p. 2.1-6, Dames & Moore 1979).
2. Irrigation for revegetated areas is 1 acre-foot per year.

Computations:

$\frac{753}{1}$ = 753 acres